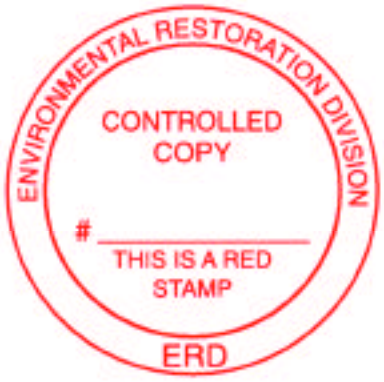
LLNL Environmental Restoration Division (ERD)
Standard Operating Procedure (SOP)

ERD SOP 1.5: Well Development—Revision: 4

AUTHOR(S):
J. Valett*



APPROVALS:	Date
Albert J Hamann Division Leader	10/20/00
Hydrogeology Group Leader	10/18/00
CONCURRENCE:	**Date**
QA Implementation Coordinator	10/2/00

*Weiss Associates

1.0 PURPOSE

The purpose of this SOP is to enhance well efficiency and subsequent water sample quality by removing materials introduced into the ground water, water-bearing formation, sand pack, and well screen during drilling and well installation.

2.0 APPLICABILITY

This procedure is applicable for all personnel performing well development operations, and should be fully reviewed prior to conducting these activities.

3.0 REFERENCES

3.1 Barcelona, M. J., J. P. Gibb, J. A. Helfrich, and E. E. Garske (1985), *Practical Guide to Ground Water Sampling*, U.S. Government Printing Office, EPA 600/2-85/104.

3.2 Driscoll, F. G. (1986), *Groundwater and Wells*, Johnson Division, St. Paul, Minnesota.

4.0 DEFINITIONS

See SOP Glossary.

5.0 RESPONSIBILITIES

5.1 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Hydrogeology Group Leader (HGL)

The HGL's responsibility is to ensure that proper procedures are followed for activities (i.e., drilling, borehole logging and sampling, monitor well installations and development).

5.3 Drilling Supervisor (DS)

The DS schedules all drilling related activities and coordinates the drilling contractor schedules and equipment needs.

5.4 Drilling Coordinator (DC)

The DC provides the interface between the DS, Subproject Leader (SL), Hydrogeologist (HG), and the field activities and is responsible for coordinating drilling and well development and purge water disposal activities and the progress of drilling activities daily.

5.5 Drilling Geologist (DG)

The DG is responsible for conducting and documenting well development activities safely and correctly per the Drilling Work Plan, and applicable operational and safety procedures, and to inform the DC, SL, and DS of any nonconformances.

5.6 Subproject Leader (SL)

The SL is responsible for the overall investigation, planning, assessment, and remediation within a study area, including decisions regarding borehole depths and well specifications.

5.7 Hydrogeologist (HG)

The HG is responsible for arranging the review of borehole, geophysical, and development logs and assisting the SL in conducting his/her responsibilities, as listed above.

6.0 PROCEDURE

The primary methods used to develop wells are surge-block/bail and air lift. These techniques are used to increase well production and reduce water turbidity by removing introduced sediments from the formation filter pack and well screen area.

6.1 Preparation

6.1.1 Perform the applicable preparation activities described in SOP 4.1, "Instructions for Field Personnel."

6.1.2 The DG should obtain relevant information on each well to be developed (e.g., drilling technique, drilling fluid losses, anticipated aquifer yield, screened interval, anticipated contaminants, etc.).

6.1.3 The DG should obtain materials listed in the Drilling Geologist Equipment Checklist (Attachment A).

6.1.4 Decontaminate all equipment used in well development per SOP 4.5, "Equipment Decontamination."

6.1.5 Obtain sufficient collection containers such as 55 gal drums or portable tankers for temporary storage of well development water according to SOP 4.7, "Treatment and Disposal of Well Development and Well Purge Fluids." At Site 300, purged water is typically discharged directly to the cuttings pit, adjacent to the well. Ensure that:

A. Containers have no leaks.

B. Containers, such as 55 gal drums, are stabilized to prevent spillage.

C. Containers are field manageable. The use of truck- or trailer-mounted tanks may be necessary for particularly large volumes of water.

D. Containers are labeled as non-potable purge water.

6.1.6 Check the source(s) of water to be introduced into the borehole. Use analyte-free water. Request analysis if none exist prior to field operations.

6.2 Operation

Well development should be performed as soon as practical after well installation. Development may be performed prior to fully installing the sanitary seal, as determined by the DS or designee.

6.2.1 Measure depth to water according to SOP 3.1, "Water Level Measurement," and measure the total depth of the well.

6.2.2 Record all information on the "Well Development Data" form (Attachment B).

6.2.3 Remove any residual drilling mud from the casing by bailing or flushing with potable water through a tremie pipe. Introduce just enough water to remove the drilling mud.

6.2.4 Segregate removed drilling mud from the formation water, if possible. Use drilling contractor's mud tank to collect unthinned drilling mud and initial muddy formation water.

6.2.5 Begin well development using a surge block/bailer based on the number of well casing volumes. Depending on site specific conditions, follow with additional surge-block/bailing, airlift, or a combination of the two methods, as described below. Continue until the water is nearly sediment-free as described below:

A. Use a surge-block/bailer until the water is relatively sediment-free (less than 3 ml/L sediment). If a well cannot produce enough formation water because the aquifer yields insufficient water, small amounts of potable water may be introduced only with the approval of the SL or DS. When most of the sediment is removed, continue development with formation water only, if possible.

B. To prevent forcing a pocket of air into the sand pack and possibly reducing the yield of the well, it is important to use dual tube airlifting. This process involves diverting an air line into an eductor pipe in the well to create a vacuum that "lifts" the ground water to the surface. Two-inch PVC as the eductor pipe, and 1-in. tremie pipe with a "J" attachment as the air line may be used. In this arrangement, the "J" end extends several inches into the bottom opening of the 2-in. PVC. At the surface, compressed air is fed through the tremie pipe, travels down through the submerged "J" tube, and travels back to the surface through the 2-in. PVC. This process creates a vacuum in the PVC casing that "lifts" the ground water out of the well and allows for easy containment of the purged water. Air lifting should start at the top of the sand pack and move down until the entire sand pack interval is developed.

C. Start dual-tube air lifting about 10 ft above the top of the screen, and use just enough air pressure to develop a flow. Gradually increase air pressure to maximize flow. Make periodic water level measurements to ensure the water level in the well casing does not fall below the top of the screen. Surge air pressure periodically to make the water column rise and fall. Move the air line down into the screen as the water clears. Note the time it takes for the water to clear between successive rounds of surging. Effective surging is indicated by decreasing time for water to clear. Ensure that the compressed air is filtered before introduction into the well. All collected purge water should be treated or disposed in accordance with SOP 4.7.

6.2.6 Visually note the initial water color, clarity, odor and pH (using pH paper) of the purge water, and record on the Well Development Data form (Attachment B). The pH is checked primarily to ensure there is no grout or cement contamination. The majority of the ground water falls in a pH range of between 7 and 9. If the pH of the purged water at the end of development is above 9.5, the condition of the well should be evaluated for grout invasion. This is especially apparent if the pH is higher at the start of development and slowly declines as more water is removed from the well, but rises to higher levels upon ceasing the purging process. Further air development may need to be performed until a lower pH is obtained.

6.2.7 Periodically record descriptions of development method, flow rate, water clarity, odor, water levels, recovery rates, quantity of water evacuated, pH, and sediment content (using a 1-liter Imhoff cone).

6.2.8 Develop the well until it is sediment free. An Imhoff cone should be used to determine when there is no further improvement in well sediment levels. As a general rule of thumb, sediment should consist of 3 ml/L or less in the cone when initial development is complete. A final pH check using pH paper should be done to ensure there is no cement contamination. Water chemistry parameters, including pH, specific conductance, temperature, and when possible, dissolved oxygen, and redox potentials, will be carefully scrutinized at the first routine sampling event to ensure the well was properly developed.

6.2.9 Contain all water produced during development. Determination of the appropriate treatment prior to disposal will be based on a chemical analysis of the water. Handle development effluent according to SOP 4.7.

6.2.10 Using flow rates and recovery rates, estimate the discharge rate at which the well can be pumped while not allowing (if possible) the water level to fall below the top of the screened section of the casing. This estimated sustainable yield of the well should be reported to the Ground Water Monitoring Sampling Coordinator (SC). In some cases, the yield is too low for any purging device. These cases should be labeled as low yielding monitoring wells or dry-out wells (SOP 2.7, "Presample Purging and Sampling of Low Yielding Monitor Wells").

6.2.11 Collect a bailed water development sample when requested by the SL. The SL will specify the required analyses. Well development samples are identified differently then routine samples and should be named using the well name followed by WD (i.e., W-123-WD). Well development samples should be collected after full recovery of the static water level, if practical. The static water level should be measured before sampling.

6.3 Post Operation

6.3.1 Perform post-work activities described in SOP 4.1, "General Instructions for Field Personnel," Section 6.3.

6.3.2 Deliver original data forms to the DMT for storage and copies to the Quality Control Reviewer for review and distribution.

7.0 QUALITY ASSURANCE RECORDS

7.1 Borehole/Well Construction Log

7.2 Chain-of-Custody Form

7.3 Document Control Logbook

7.4 Well Development Data Form

8.0 ATTACHMENTS

Attachment A—Drilling Geologist Equipment Checklist

Attachment B—Well Development Data Form

Attachment A

Drilling Geologist Equipment Checklist

Drilling Geologist Equipment Checklist

____ 300-ft weighted tape
____ Any applicable permits (i.e., excavation, utility clearance, burn permits)
____ Applicable documents (i.e., SSP, OSPs, SOPs, work plan, sample plan, etc.)
____ Appropriate clothing (i.e., coveralls, steel-toed safety shoes, gloves)
____ Barricades/traffic cones
____ Buckets and brushes
____ Caution tape
____ Company ID sign for vehicle
____ Cooler with ice
____ Core boxes, marking pens
____ Deionized water
____ Detergents (Alconox, Liquinox)
____ Disposable Teflon or polyethylene bailers
____ Document control logbook
____ Field forms (i.e., borehole/well constructions form, daily field report forms)
____ Field notebook
____ Fire extinguisher
____ First aid kit
____ Glass jars
____ Grain-size sieves
____ Hard hat
____ Hearing protection
____ Imhoff cone
____ Measuring wheel
____ Munsell soil/rock color chart
____ Nitrile or latex sampling gloves
____ pH paper
____ PID or FID, or gamma/beta meter if required
____ Rock hammer
____ Safety glasses
____ Sample containers/labels
____ Signs listing responsible persons, restricted entry, hearing protection/hard hat/safety glasses/safety shoes required
____ Soil sample tubes
____ Steel measuring tape with engineering scale
____ Steel spatula
____ Stopwatch or watch with second hand
____ String
____ Teflon tape (4 in. wide)
____ Water-level meter
____ Zip-Loc plastic bags

Attachment B

Well Development Data Form

WEISS ASSOCIATES

WELL DEVELOPMENT DATA

By: _____ Sheet _____ of _____

Well No. / Location: _____ Job Name: _____

Date: _____ Job No: _____

Development Method(s): _____

Depth to Water Before Development (ft): _____ Sounded Depth (ft): _____

Screened Interval (ft-ft): _____ Spec. Depth (ft): _____ Well Diameter (in): _____

Time	Depth to Water (ft)	Gallons Pumped	Flow Rate (gpm)	Comments (water clarity, odor, methods, sounded depth, etc.)

Well Development Summary

Depth to Water During Pumping (ft): _____ Approximate Yield: _____

Depth to Water After Development (ft): _____ Average Pumping Rate (gpm): _____

Sounded Depth After Development (ft): _____ Pumping Rate Range (gpm): _____

Total Pumping Time (min): _____ Total H_2O Injected (gal): _____

Total Amount Evacuated (gal): _____

Note: All depths measured in feet below ground water surface (bgs).

Attachment B. Well development data form.